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THE DISTRIBUTION AND FOOD HABITS OF *NEPHTYS BUCERA* EHLERS, 1868, (POLYCHAETA: NEPHTYIDAE) IN THE SURF ZONE OF A SANDY BEACH

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Abstract.—*Nephtys bucera* was more abundant below mean low water (MLW) than above, in the surf zone of an exposed sandy beach along the southern coast of New Jersey. Food items found in the digestive tracts of 111 *N. bucera,* collected over several years, were identified and counted. One hundred preserved worms ranged in length from 51 to 166 mm, wet weight from 70 to 3400 mg, and dry weight from 13 to 506 mg. Juvenile wedge clams, *Donax variabilis,* were the most common and abundant prey, occurring in 65.5% of worms with food and accounting for 81.3% of all food items. Clams, all young-of-the-year, were consumed whole and digested in their valves; they ranged in shell length from 1.1 to 6.4 mm ($\bar{x}$ 2.47 ± 0.82). The spionid polychaete, *Scolelepis squamata,* was next in dietary importance (incidence 32.3%, abundance 10.1%). This potentially important prey species dominates the intertidal area above MLW for all except three winter months, and thus there is usually little spatial overlap with *Nephtys.* The crustaceans *Amphiporeia virginiana* and *Emerita talpoida* appeared to be incidental prey. Thus *N. bucera* is an opportunistic carnivore (there was no evidence of deposit feeding) influencing the population dynamics of several surf-dwelling invertebrates. *Nephtys bucera* itself is a minor prey item for at least one species of juvenile fish inhabiting the surf zone, viz., the northern kingfish *Menticirrhus saxatilis.*

Nephtys bucera, a relatively large sand-dwelling polychaete, is distributed from the Gulf of Saint Lawrence to South Carolina, and in the Gulf of Mexico from Florida to Mississippi (Verrill 1873; Hartman 1945, 1951; Carpenter 1956; Sanders 1958; Pettibone 1963; Croker 1970, 1977; Wass 1972; Day 1973[1]; Gardiner 1975; Kinner and Maurer 1978; Zingmark 1978; Croker and Hatfield 1980; Garlo 1980). It is found from the intertidal zone to a depth of about 200 m (Pettibone 1963, Day 1973, Zingmark 1978), primarily in sand containing little organic matter, and has been reported in concentrations ranging from 10 to 419 worms/m^2 (Carpenter 1956, Sanders 1958, Kinner and Maurer 1978).

Clark (1962) reviewed the scanty literature on the genus and pointed out that, with few exceptions, all species were carnivorous. In apparently the only published information on the food habits of *N. bucera,* Croker (1977) listed it as an omnivore, but gave no evidence for such a designation. The purpose of the present study was to determine the types of prey consumed by *N. bucera,* to relate this information to potential prey in its habitat, and to discuss its role in the food web of the surf zone.

[1] Perkins (1980) examined all of the specimens from the coast of North Carolina identified as *N. bucera* by Day (1973), and found that 17 specimens were *N. bucera,* 43 *N. simoni* (a new species) and 13 may have been the young of *N. picta.*

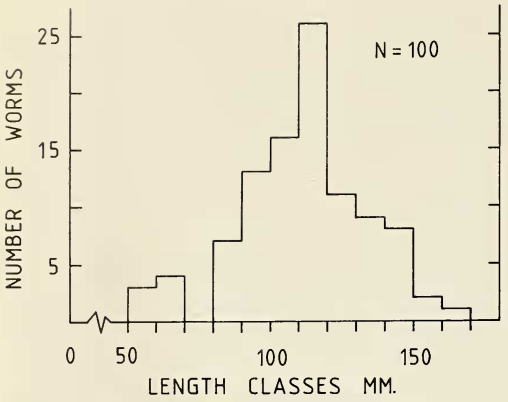

Fig. 1. The length-frequency distribution of 10 mm size classes of *Nephtys bucera* (preserved) from the surf zone at Seven Mile Beach, Avalon, New Jersey.

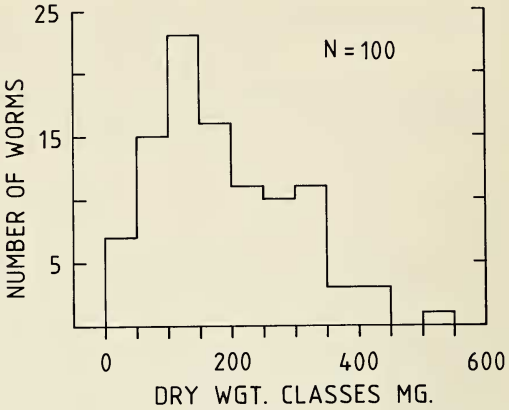

Fig. 2. The dry weight-frequency distribution of 50 mg size classes of *Nephtys bucera* (preserved).

Materials and Methods

Worms were collected in the surf of an exposed sandy beach at Avalon, New Jersey (39°04′43″N, 74°44′05″W) from 1977–1985. This was the site of an extended study (1977–1979) dealing with interactions of the benthos and nekton (McDermott 1983). The spatial distribution of *Nephtys* was determined from the analyses of 704 benthic cores (each 20 cm deep and 46 cm^2) taken along transects run perpendicular to the shore from above mean high water (MHW) to 50 m seaward of mean low water (MLW). Few of the worms collected in these cores were used for food analyses because most were damaged.

The majority of worms used for food determinations were collected during spring ebb tides by turning over the exposed sediments with a long-handled spade. Digging was usually done in a 20 m wide region (parallel to the shore) below MLW, where worms were more abundant than inshore of this mark. Worms were placed immediately into capped tubes containing ~15% sea water formalin. This isolation was to insure recovery of any food regurgitated from the gut, but no evidence of regurgitation was subsequently found.

The following determinations were made on each worm prior to examination: total length to the nearest mm, width of the prostomium (posterior to base of antennae) to the nearest 0.1 mm, and damp weight to the nearest 10 mg. Dry weight and ash-free dry weight (AFDW) to the nearest mg, were determined after examination.

Contents of the entire digestive tract of each worm were examined with the aid of a dissecting microscope, and prey species were identified and counted. Shell lengths of one prey item, *Donax variabilis,* were measured to the nearest 0.1 mm with a calibrated ocular micrometer.

Results

Eleven of the 111 *N. bucera* used for food analyses were slightly damaged and were not measured or weighed. The remaining worms ranged in length from 51 to 166 mm ($\bar{x}$ 110.9 mm ± 22.7) (Fig. 1), in wet weight from 70 to 3400 mg ($\bar{x}$ 1167.1 mg ± 696.3), and in dry weight from 13 to 506 mg ($\bar{x}$ 187.2 mg ± 108.1) (Fig. 2). The mean AFDW/dry weight ratio for 49 worms collected in the fall of 1980 and 1983 was 0.832 ± 0.051. Regression equations and correlation coefficients for various relationships follow:

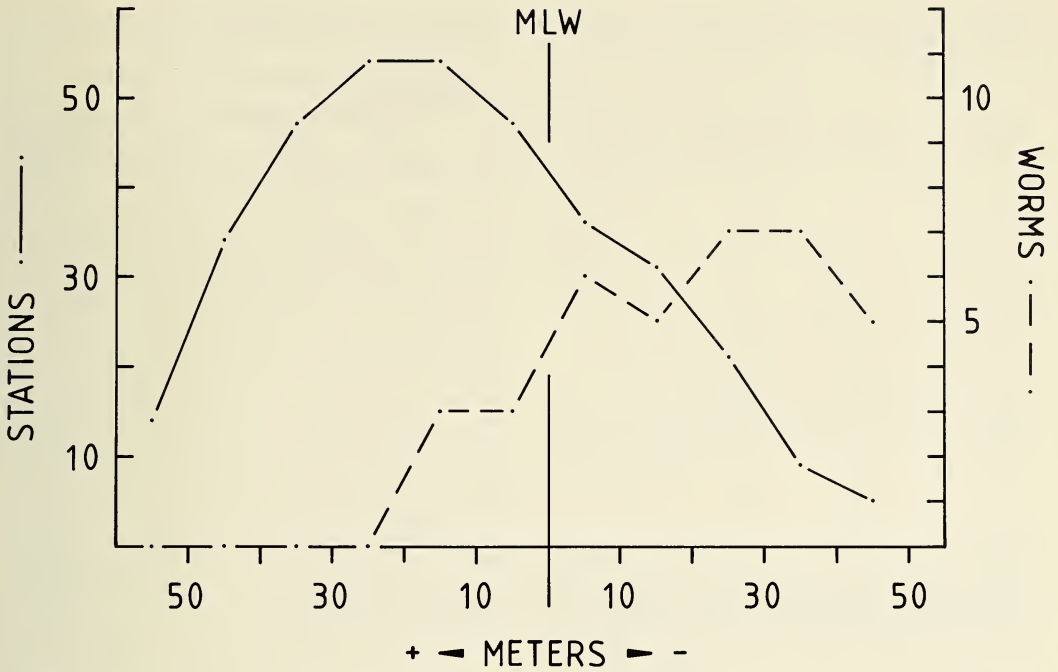

Fig. 3. The distribution of *Nephtys bucera* at Seven Mile Beach, Avalon, New Jersey, in relation to the mean low water mark (MLW), based on 704 cores (each 20 cm deep, 46 cm^2) taken from 1977–1979 at 250 stations above and 102 stations below MLW, plotted in 10 m intervals. The zone occupied by the dominant polychaete *Scolelepis squamata* is located approximately between 10 and 30 m above MLW, during all but three winter months.

dry wt (Y) vs. wet wt
$Y = 9.3500 + (0.1525)X$ $R = 0.98$
dry wt (Y) vs. length
$\log Y = -3.8882 + (2.9832)X$ $R = 0.92$
wet wt (Y) vs. length
$\log Y = -3.6389 + (3.2469)X$ $R = 0.93$
AFDW (Y) vs. dry wt
$Y = 0.3726 + (0.8295)X$ $R = 0.99$
pro. w (Y) vs. length*
$Y = 0.1747 + (0.0127)X$ $R = 0.91$

* prostomium width of 90 worms (72 from those examined for food and 18 juvenile worms from the benthic cores).

Core samples revealed that small juvenile worms occurred in the surf zone during the summer months (June to the middle of September), when the water temperatures exceeded 15°C. These juveniles (15 of 23 were measurable) ranged in length from 5.5 to 42.0 mm ($\bar{x}$ = 19.0 mm ± 11.3; 10 worms were below 20 mm), and in dry weight from 0.1 to 15.7 mg ($\bar{x}$ 2.3 mg ± 4.3). They are not included in Figs. 1 and 2, and their gut contents were not analyzed.

Six *N. bucera* were collected in 500 cores taken above MLW, and 30 were recovered from 204 cores below MLW (Fig. 3). The ratios of worms to cores were 0.012 and 0.147, respectively, approximating 2.5 worms/m^2 inshore and 32 worms/m^2 offshore of MLW. Thus *N. bucera* is considerably more abundant below the MLW mark, only slightly overlapping the narrow (20 m wide band) *Scolelepis* zone, which is found in the mid-intertidal region for most of the year. During the winter months (particularly January through March), however, when the *Scolelepis* population moves to

Table 1.—Incidence and total numbers of food items in the digestive tracts of *Nephtys bucera* collected in the surf zone of Seven Mile Beach, Avalon, New Jersey.

Date of collection	Number of worms		Incidence of food items					Unidentified crustacean fragments
	Examined	With food	*Scolelepis*	*Donax*	*Amphi-poreia*	Amphipod fragments	*Emerita*	
13-5-78	1	0						
24-7-78	1	1	1					
14-10-78	3	3		2	1			1
28-10-78	5	4		1	2	2		
7-7-79	3	3	3					
16-10-79	3	1						1
27-3-80	7	2	2					
12-10-80	7	7		7			4	
22-11-80	19	16	8	13	2	1		
9-9-83	5	4	2	2				
5-11-83	24	18	13	4	1			
3-6-85	33	31		30	8	1		
Totals	111	90	29	59	14	4	4	2
Numbers of each item			34*	278	18	4*	5	2*

* Where no anterior ends were found, fragments were calculated as one individual.

the lower intertidal and subtidal region (McDermott 1983), there may be more overlap of the populations. This assumes that *Nephtys* does not migrate also.

Donax variabilis was the most common and most abundant prey species found in the digestive tracts of 111 worms examined from 1978 to 1985 (Table 1). These clams occurred in 65.6% of worms with food, amounted to 81.3% of all food items, and were ingested by worms from all size classes. The small spionid polychaete *Scolelepis squamata* was next in importance, while the two crustaceans, *Amphiporeia virginiana* and *Emerita talpoida,* appeared to be incidental prey. The mole crabs belonged to the 1980 year-class (carapace lengths: 3.5, 4.0, 4.5 and 5.1 mm). Most of the amphipod fragments were probably from *Amphiporeia.* Eleven additional damaged worms were also examined, and in these *Donax* was dominant over *Scolelepis* and *Emerita.* Sand was not often found in the digestive tracts of *Nephtys,* but when found it was usually in small amounts in the rectum.

Clams are consumed whole, i.e., the shells are not crushed by the two conical pharyngeal jaws of the worm during ingestion. Broken shells were found sporadically, but this was attributed to damage caused during dissection. The clams were all young-of-the-year, ranging in shell length from 1.1 to 6.4 mm ($\bar{x}$ = 2.47 mm ± 0.82). The length frequency distribution of all undamaged clams recovered from *Nephtys* appears in Fig. 4. Clams were usually oriented with their long axes parallel to the gut of the worm, thus the longest clam (6.4 mm) required a buccal opening equal only to its height (4 mm). This clam was one of two recovered from one of the longest worms in the collection (149 mm long, 441 mg dry wt). Up to 18 clams were found in a single worm (a specimen 118 mm long, 243 mg dry wt), and they ranged in length from 1.9 to 3.2 mm ($\bar{x}$ = 2.38 ± 0.33). Nine of these clams were packed into a swollen part of the gut just posterior to the muscular pharynx.

Most of the clams recovered were in the 1.5 to 2.9 mm category (Fig. 4), and practically all of the larger clams were from the 22-11-80 collection (2.8 to 6.4 mm long, $\bar{x}$ 4.41 mm ± 0.85, n = 30). Worms in this

collection were not significantly larger than those from other collections, indicating that worms collected at other times would have been capable of ingesting larger clams had they been available.

Clams are digested within their shells, the two valves usually remaining attached by the ligament even after complete digestion of the tissues. Some tightly closed clams with little or no digestion were found in the lower gut. Whether some clams escape digestion and are redeposited alive back into the sediments with the feces, is a question that must be left to laboratory experimentation. K. Fauchald's (Smithsonian Institution, pers. comm.) observations on several species of nephtyids, suggest that following digestion bivalve shells of the size reported here are probably regurgitated because the anal openings of these worms are too small to allow passage in the normal manner.

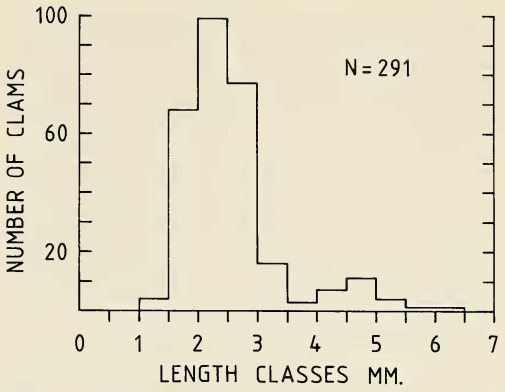

Fig. 4. The length-frequency of 0.5 mm size classes of *Donax variabilis* removed from the digestive tracts of *Nephtys bucera.*

Discussion

Nephtys bucera appears to be an opportunistic carnivore, feeding on the invertebrates most available to them in the surf. It was found previously that *Scolelepis, Donax, Amphiporeia* and *Emerita* are the dominant benthic species in this particular habitat along the coast of New Jersey (McDermott 1983).

The virtual lack of significant amounts of sand in the digestive tracts of *N. bucera,* with or without macrofauna, certainly obviates any contention that this species is a deposit feeder. Sanders' (1956, 1960) observation that *N. incisa* is a non-selective detritus feeder was viewed by Clark (1962) as a condition probably peculiar to the species, and perhaps related to the unusually high concentrations of the worm in the offshore waters of Long Island Sound and Buzzards Bay, Massachusetts. Sanders' (1960) contention that it would not be feasible for the worm to be primarily a predaceous feeder because of its dominance in the soft-bottom community of Buzzards Bay, might be reevaluated in light of what appears to be a great diversity and relative abundance of potential prey species tabulated for the area. Suspension feeding was recently suggested for the same species by Davis (1979).

Clark (1962) noted that the European species, *N. cirrosa* and *N. hombergi,* while usually not packed with food, fed mainly on a variety of polychaetes. Never were their digestive tracts filled with sand. Warwick and Price (1975) also concluded that *N. hombergi* was a carnivore, but their evidence was meager, and they were concerned that no other suitable macrofaunal animals of a lower trophic level were available in the Lynher Estuary (England) to maintain the large population of *Nephtys.* Ockelmann and Muus (1978) determined that *Nephtys* spp. from Danish waters fed on foraminiferans, small molluscs (including the small montacutid bivalve *Mysella bidentata*) and smaller polychaetes. *Nephtys caeca, N. hombergi* and *N. longosetosa* all occurred in their study areas, but the food of each was not specified. Brown (1964) considered *N. capensis* to be an impartial feeder that "draws the line only at plant material," but he gave no substantiating data. Srinivasa Rao and Rama Sarma (1978) concluded that *N. oligobranchia* from the east coast of India feeds primarily on polychaetes. In their

recent review of food and feeding in polychaetes, Fauchald and Jumars (1979) concluded that nephtyids are predominantly carnivores, but they admitted that there is a scarcity of information on the subject.

Ockelmann and Muus (1978) observed that the shells of *Mysella bidentata* are crushed by the pharyngeal jaws of European *Nephtys* spp. This did not appear to be the case with *Donax* ingested by *N. bucera.* Possible differences in feeding behavior and size of the jaws among nephtyids and the physical properties of bivalve shells, may be related to how small bivalves are handled by these predators.

Although *Donax* was the dominant food item of *N. bucera,* further more intensive seasonal observations from field collections, as well as laboratory experiments, are necessary in order to determine if it has a preference for this clam. It may be suggested that as the population of *Scolelepis* moves offshore in the winter it becomes a more important food source in the diet of *N. bucera,* but the sporadic nature of my sampling does not lend itself to a seasonal analysis. It appears likely that other species of haustoriid amphipods, belonging to the same subfamily as *Amphiporeia* (Pontoporeiinae) and to the subfamily Haustoriinae, and known to exist in relatively small numbers in the *Nephtys* region (McDermott 1983), would be suitable prey.

Nephtys' role in the food web of the shallow surf zone is that of a predator, influencing (to an undetermined extent) the population dynamics of *Donax, Scolelepis* and various benthic crustaceans. All of the latter have been shown to be important prey for a variety of fishes that inhabit the surf zone (McDermott 1983). *Nephtys,* in turn, serves as occasional food for juvenile northern kingfish (*Menticirrhus saxatilis*); single specimens were found in the stomachs of four of the 159 fish examined. The kingfish feeds predominantly on *Scolelepis,* which makes up over 80% of its diet in the surf (McDermott 1983). *Nephtys* was not observed in the stomach contents of 236 juvenile spot (*Leiostomus xanthurus*), also a member of the Sciaenidae, or in other species of fishes examined from the same environment.

Further, more detailed studies on the life history of *N. bucera* will require improved sampling techniques. The methods used in the present study are not adequate for obtaining sufficient numbers of worms. Two devices, a suction corer and a scoop dredge, specifically developed recently for use in the surf zone by Fleischack et al. (1985) may hold promise for obtaining adequate samples of *Nephtys* and other invertebrates living in this turbulent region.

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